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TANK TESTS OF A POWERED DYNAMIC MODEL OF A FLYING BOAT HAVING AN AFTERBODY LENGTH-BEAM RATIO OF 4.7 - LANGLEY TANK MODEL 203C-1

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MEMORANDUM REPORT

for the

Bureau of Aeronautics, Navy Department

TANK TESTS OF A POWERED DYNAMIC MODEL OF A FLYING BOAT HAVING AN AFTERBODY LENGTH-BEAM RATIO OF 4.7 - LANGLEY TANK MODEL 203C-1

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SUMMARY

Tank tests of a $\frac{1}{10}$-size model of a hypothetical flying boat having an afterbody length-beam ratio of 4.7 were made in Langley tank no. 1 to determine the take-off and landing stability and the resistance characteristics.

The range of stable trims was less than that of models with conventional afterbody length-beam ratios, but the range of stable positions for the center of gravity was approximately the same as that of most models. The landing stability with the depth of step used in the tests was satisfactory. The hump trim and resistance were lower than those for models with conventional afterbody length-beam ratios.

INTRODUCTION

In view of the present interest in the hydrodynamic characteristics of flying boats with long afterbodies, the results of tank tests of a $\frac{1}{10}$-size powered dynamic model having an afterbody length-beam ratio of 4.7 are made available in this report. These data were obtained as part of a recent investigation of the effect of hull length-beam ratio on the stability and spray characteristics. The spray characteristics of the parent model, which had a forebody length-beam ratio of 5.2 and an afterbody length-beam ratio of 3.8, have been described in reference 1.

The tests were made at loadings comparable to those for hulls with conventional length-beam ratios. These loadings correspond to high values of load coefficient because of the relatively narrow beam of the parent model, but the results are considered indicative of the hydrodynamic characteristics of hulls with afterbody lengths greater than normal.

DESCRIPTION OF THE MODEL

The model, designated as model 203C-1, was a $\frac{1}{10}$-size model of a flying boat similar to the Boeing XPBB-1 except for the form and proportions of the hull. The lines of the hull and the general arrangement are shown in figures 1 and 2, respectively, and the model particulars are presented in table I. The model was the same as model 203A described in reference 1 with the following changes: the length of the afterbody was increased 8.5 inches by inserting a spacer aft of the step, and the depth of step was increased 0.39 inch by raising the afterbody. The length of the afterbody therefore was 46.14 inches (4.7 beams), and the depth of step was 1.28 inches (13 percent beam).

APPARATUS AND PROCEDURE

The tests were made in Langley tank no. 1, which is described in reference 2. The towing apparatus and test procedures are described in reference 3.

In order to provide data from which the load on the water can be approximated, the aerodynamic lift and pitching moments were determined with the flaps deflected 20°. This deflection was used throughout the remainder of the investigation. The results of the aerodynamic tests, with power, are presented in figure 3. Aerodynamic lift and pitching moment coefficients, with and without power, are presented in figure 4. The center of moments was at 24 percent mean aerodynamic chord.

The trim limits of stability and the range of stable positions for the center of gravity were determined at gross loads of 61.5 and 81.5 pounds (62,000 and 82,000 pounds, full size) and full power. Take-off runs were made with fixed elevator deflections of 0°, -10°, and -20°.

The landing stability was investigated at gross loads of 61.5 and 81.5 pounds, positions of the center of gravity of 28 and 36 percent mean aerodynamic chord, and one-quarter power.

The resistance was measured for the complete model at gross loads of 61.5, 71.5 and 81.5 pounds with the center of gravity at 28 percent mean aerodynamic chord, an elevator deflection of -10°, and zero power. The windage tare of the towing gear was deducted from the measured resistance.

RESULTS AND DISCUSSION

The trim limits of stability are plotted against Δ/V^2 (Δ is the load on the water, pounds, and V is the speed, fps) in figure 5. The range of stable trims varies from 3° at speeds just beyond the hump to 5° at speeds near take-off. This range of stable trims is less than that obtained for models with conventional length-beam ratios.

The difference between the upper limit, increasing trim, and the upper limit, decreasing trim, is approximately 1° at high speeds. This difference is approximately the same as that obtained for other models with deep steps.

The variation in trim with speed for take-off at positions of the center of gravity from 24 to 36 percent mean aerodynamic chord is shown in figure 6. The trim limits of stability are also included in this figure. Summary plots of the maximum amplitude of porpoising (obtained from data shown in fig. 6) are presented in figure 7. With a gross load of 61.5 pounds and a constant elevator deflection of -10°, no porpoising occurs at positions of the center of gravity between 25 and 28 percent mean aerodynamic chord and porpoising does not exceed 2° amplitude at positions between 24 and 32 percent mean aerodynamic chord. With a gross load of 81.5 pounds, this range is slightly reduced. The range of stable positions of the center of gravity for model 203C-1 is about equal to that for other models tested in the Langley tanks.

Records of the variation of trim and draft during landing are presented in figures 8 and 9. Although the model shows a slight tendency to skip at high trims, the motion is not violent and the landing stability is considered satisfactory.

The curves of total resistance and trim for model 203C-1 are presented in figure 10 together with data for a $\frac{1}{10}$-size model of the XPBB-1 at a gross load of 64.5 pounds, reference 4. The hump trim for model 203C-1 varies from 9.2° at a gross load of 61.5 pounds to 10.4° at a gross load of 81.5 pounds. Both the hump trim and resistance are lower for model 203C-1 than for the model of the XPBB-1. Unpublished results of resistance tests of model 203A are in good agreement with those of the XPBB-1. The difference in hump resistance of model 203C-1 and the model of the XPBB-1 is therefore attributed principally to the relatively low trim obtained with the long afterbody of model 203C-1.

Observation of the spray characteristics of model 203C-1 indicate that the spray in the propellers and on the flaps is slightly greater and the spray on the tail is slightly less for model 203C-1 than for the parent model 203A, reference 1.

CONCLUDING REMARKS

The tests of a dynamic model with a forebody length-beam ratio of 5.2 and with an afterbody length-beam ratio of 4.7 indicate that the range of stable trims is less than that obtained for models with conventional length-beam ratios.

The range of stable positions of the center of gravity is about equal to that obtained for most models tested in the Langley tanks.

The landing stability with a depth of step of 13 percent beam is satisfactory.

The hump resistance and trim is less than that of a model of the Boeing XPB3-1 which has a forebody length-beam ratio of 3.6 and an afterbody length-beam ratio of 2.7. This difference is attributed to the decrease in trim obtained with the long afterbody.

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REFERENCES

1. Olson, Roland E., and Bell, Joe W.: Spray Characteristics of a Powered Dynamic Model of a Flying Boat Having a Hull with a Length-Beam Ratio of 9.0. NACA ARR No. L5I29, 1946.

2. Truscott, Starr: The Enlarged N.A.C.A. Tank, and Some of Its Work. NACA TM No. 918, 1939.

3. Olson, Roland E., and Land, Norman S.: The Longitudinal Stability of Flying Boats as Determined by Tests of Models in the NACA Tank. I - Methods Used for the Investigation of Longitudinal-Stability Characteristics. NACA ARR, Nov. 1942.

4. King, Douglas A., and Mas, Newton A.: Effects on Low-Speed Spray Characteristics of Various Modifications to a Powered Model of the Boeing XPBB-1 Flying Boat. NACA ACR No. L5F07, 1945.

TABLE I.- MODEL PARTICULARS - MODEL 203C-1

Item	Model 203C-1
Hull:	
Beam maximum, in.	9.85
Length of forebody, in.	51.04
Length of afterbody, in.	46.14
Length of tail extension, in.	19.47
Length over-all, in.	116.65
Length-beam ratio	9.9
Type of step	Transverse
Depth of step at keel, in.	1.28
Angle of dead rise at step, excluding	
Excluding chine flare, deg	20
Including chine flare, deg	15.9
Angle of forebody keel, deg	0
Angle of afterbody keel, deg	5.4
Angle of sternpost to base line, deg	8.2
Angle of forebody chine flare at step, deg .	0
Wing:	
Area, sq ft	18.26
Span, in.	167.65
Root chord, in.	19.20
Angle of incidence, deg	4
Mean aerodynamic chord, M.A.C.	
Length, projected, in.	16.48
Leading edge aft of bow, in.	43.04
Leading edge forward of step, in.	8.0
Leading edge above base line, in.	18.34
Horizontal tail surface:	
Area, sq ft	3.33
Span, in.	51.6
Angle of stabilizer to wing chord, deg . . .	-4
Elevator root chord, in.	3.84
Elevator semispan, in.	20
Length from 25-percent M.A.C. of wing to	
hinge line of elevators, in.	59.4
Height above base line, in.	22.80
Propellers:	
Number of propellers	2
Number of blades	3
Diameter, in.	19.8
Angle of thrust line to base line, deg . . .	2
Angle of blade at 0.75 radius, deg	14
Clearance above keel line, in.	9.9

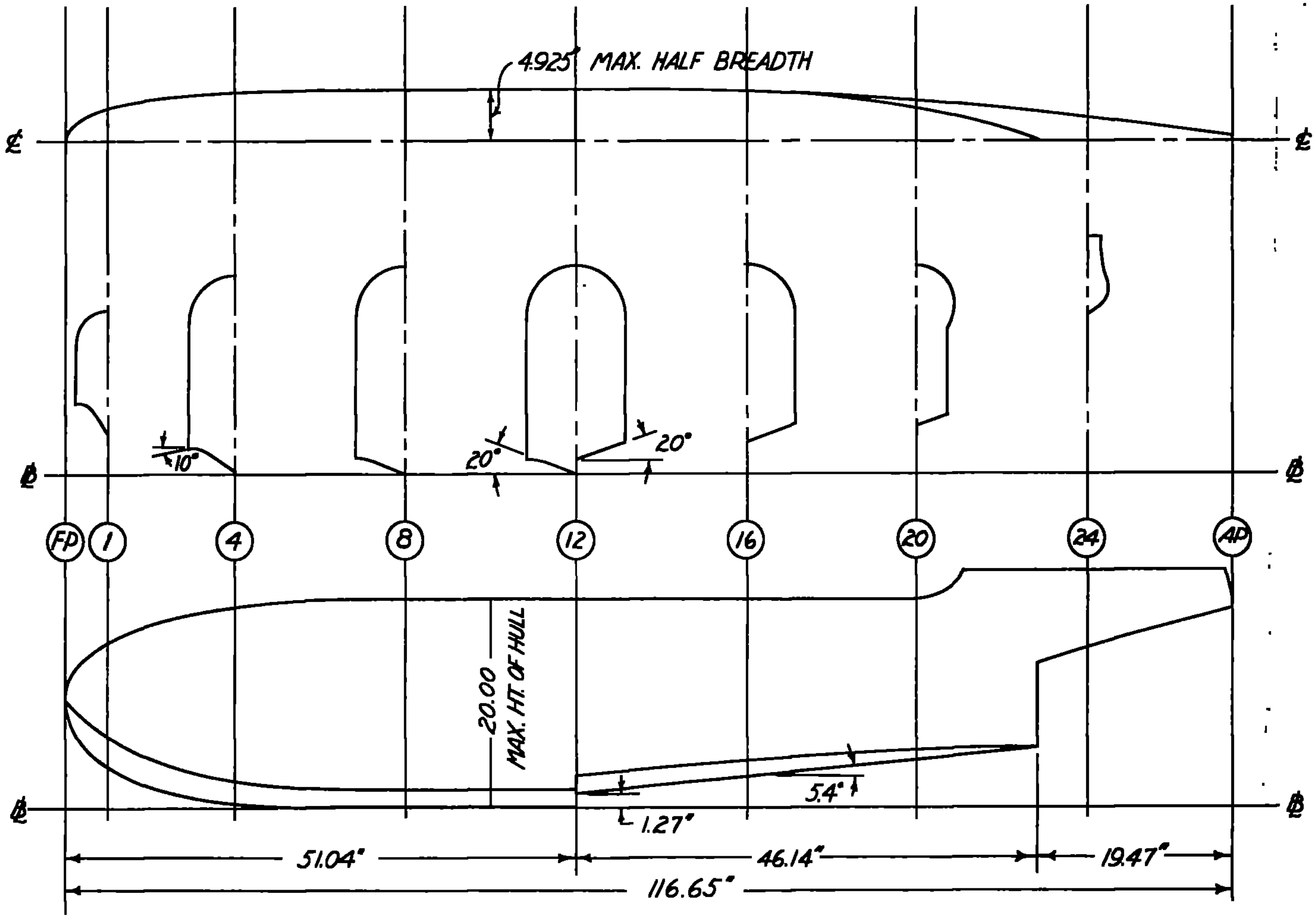

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FIGURE 1 .- MODEL 203C-1. LINES OF HULL.

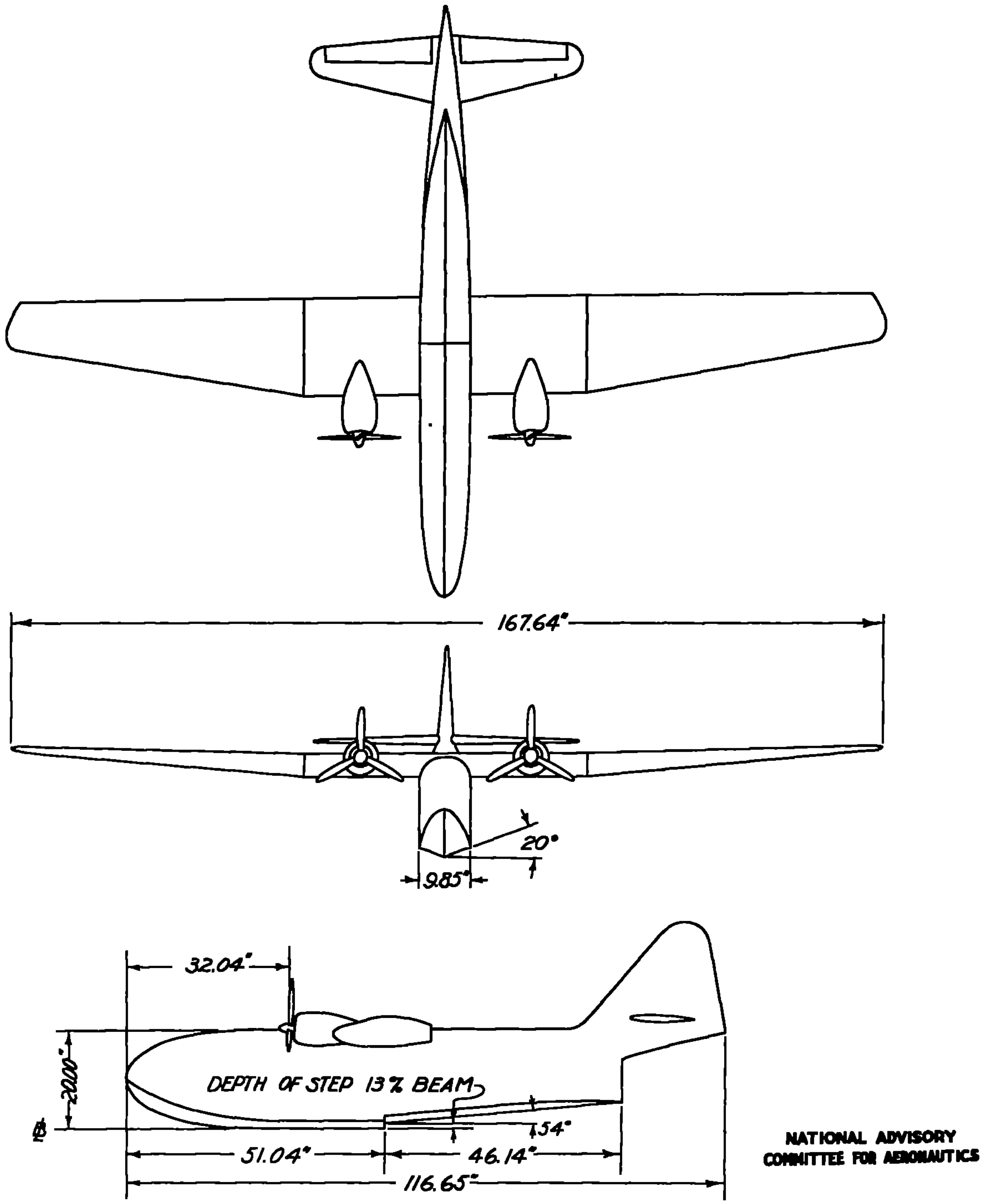
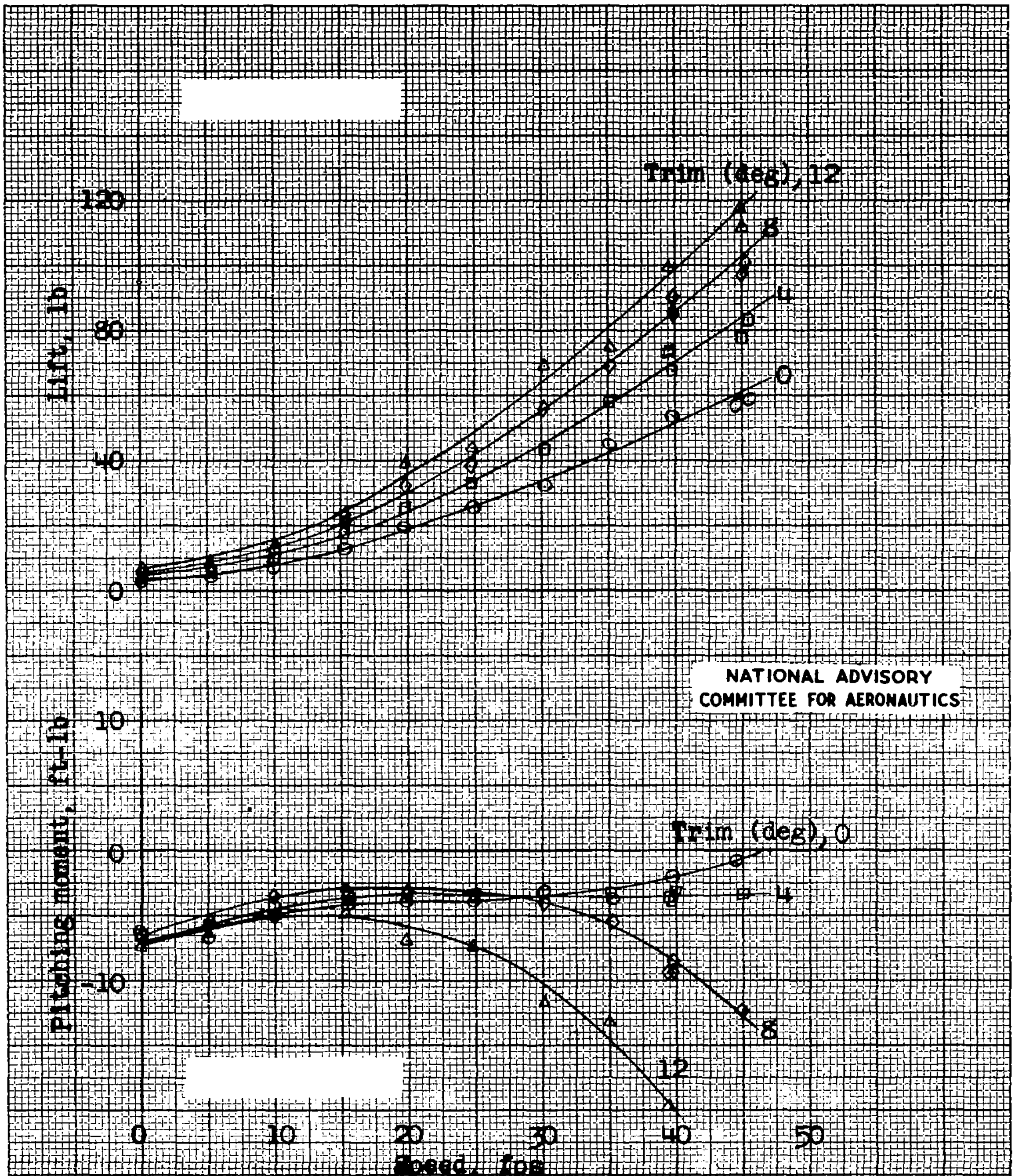
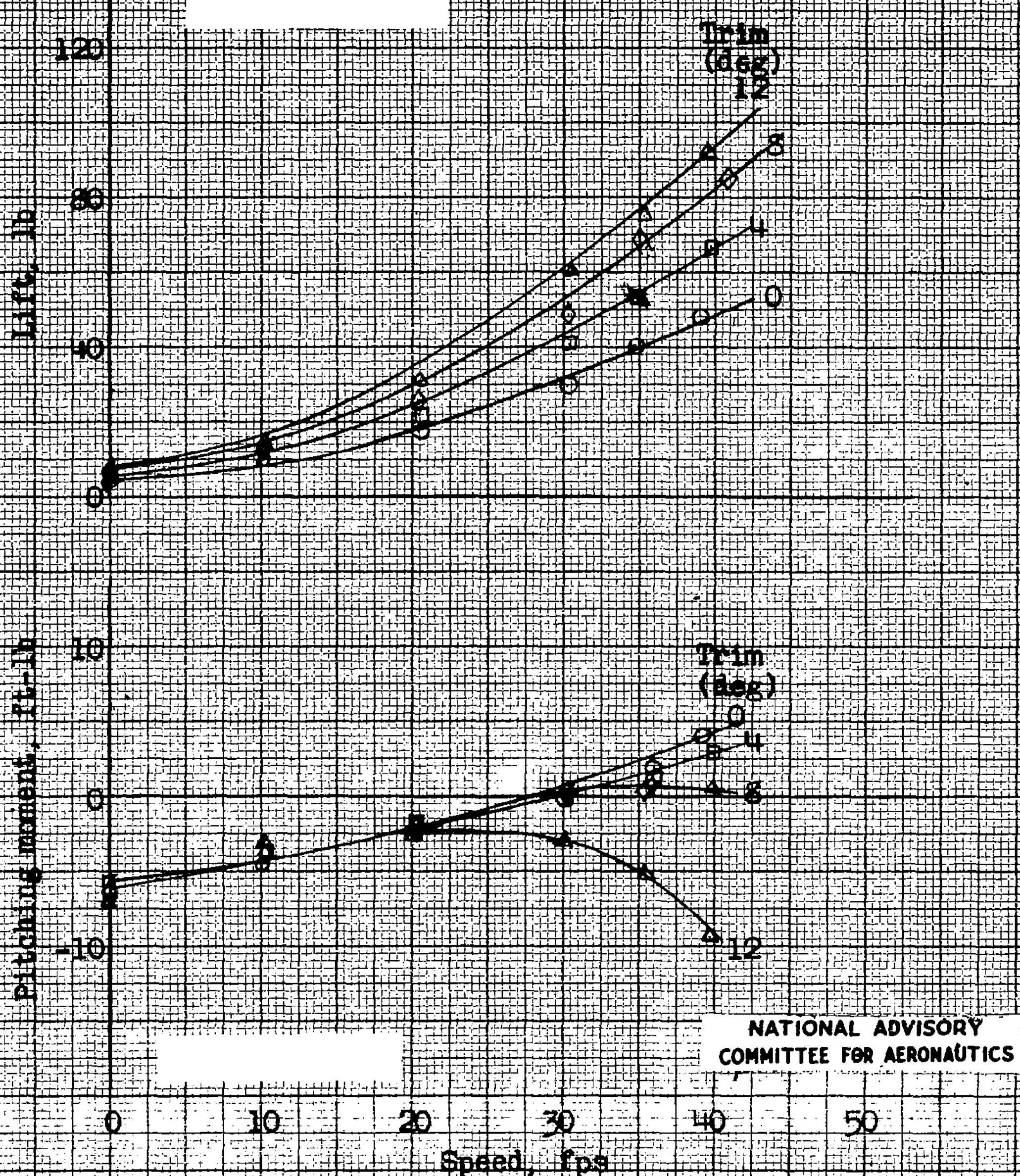


FIGURE 2 .- MODEL 203C-1. GENERAL ARRANGEMENT. 1566



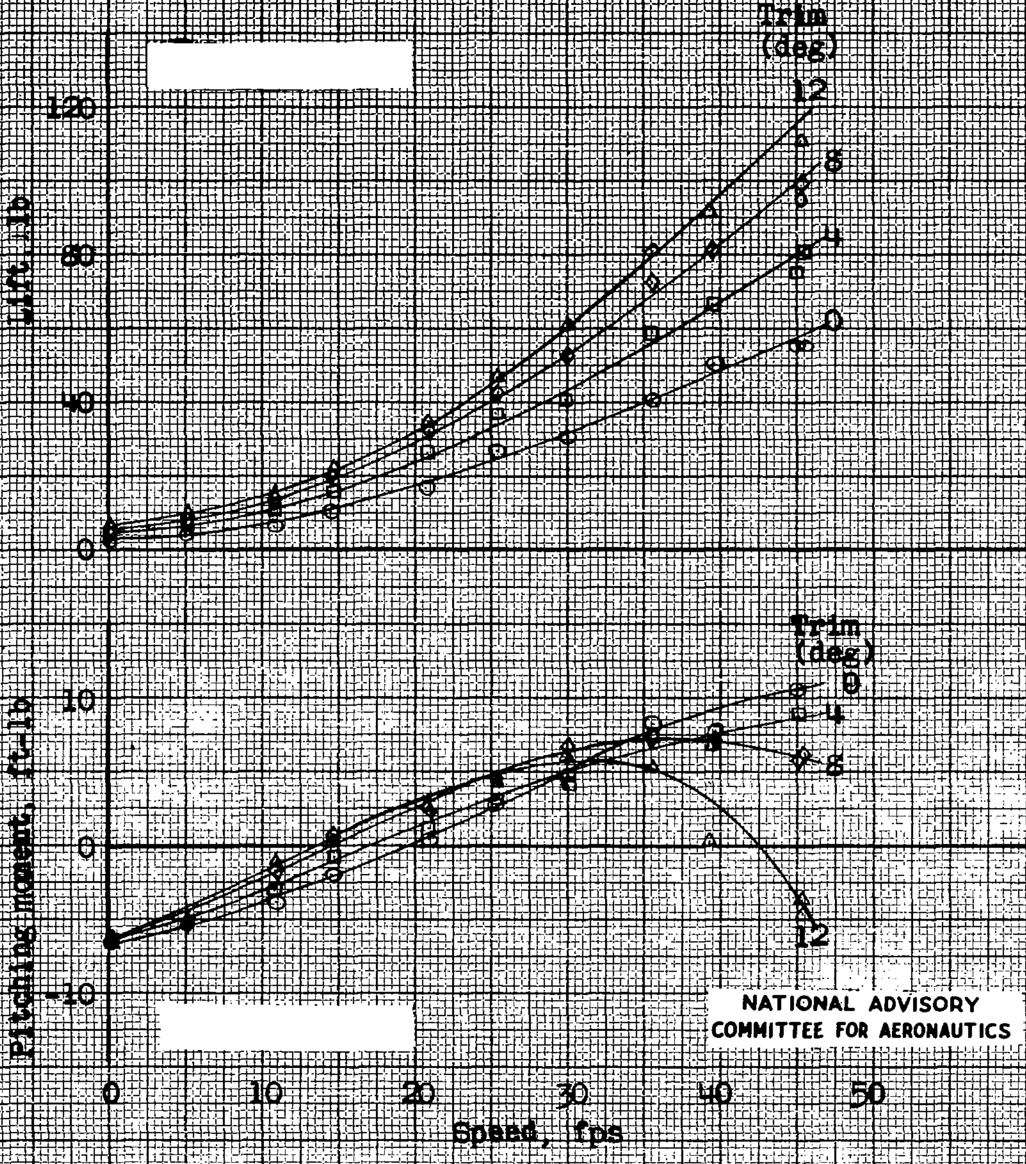
(a) Elevator deflection, 0°.

Figure 3 .- Variation in aerodynamic lift and pitching moment with speed. Full power, 4550 rpm; center of gravity 24 percent M.A.C.; flap deflection, 20°.



(b) Elevator deflection, -10°.

Figure 3.- Continued.



(c) Elevator deflection, -20°.

Figure 3.- Concluded.

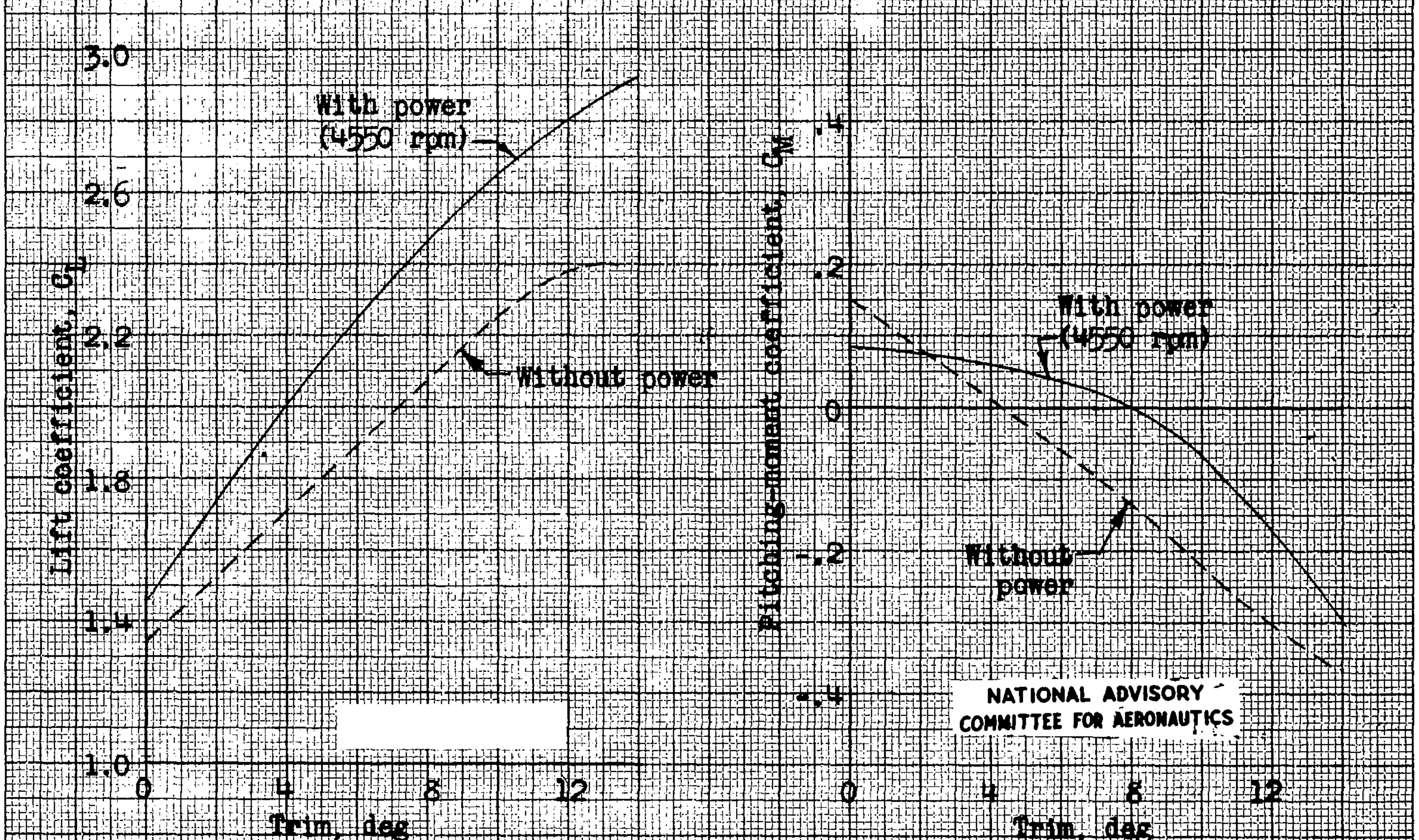


Figure 4.- Aerodynamic lift and pitching-moment coefficients. Center of gravity, 24 percent mean aerodynamic chord. Flap deflection, 20°; elevator deflection, -10°.

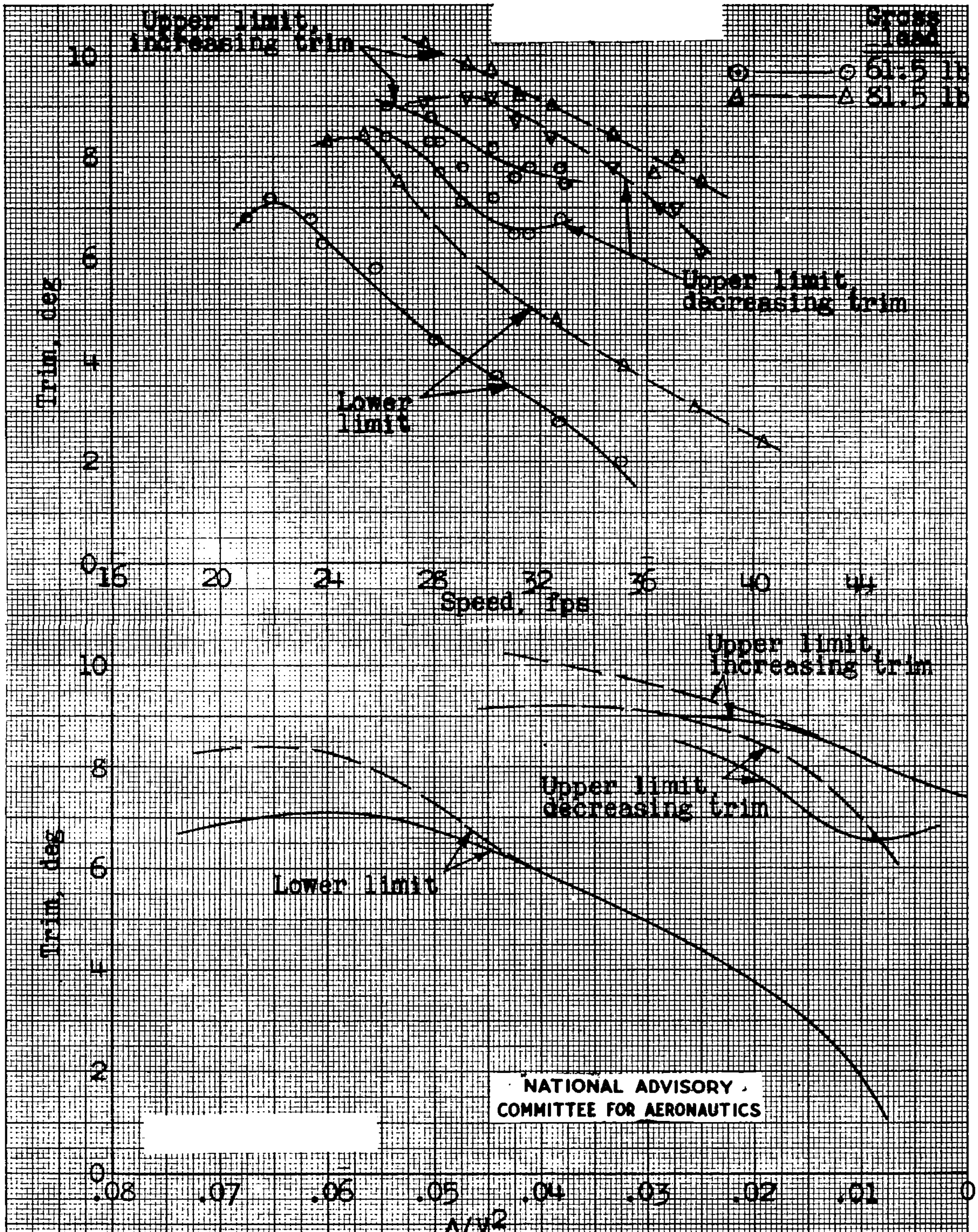
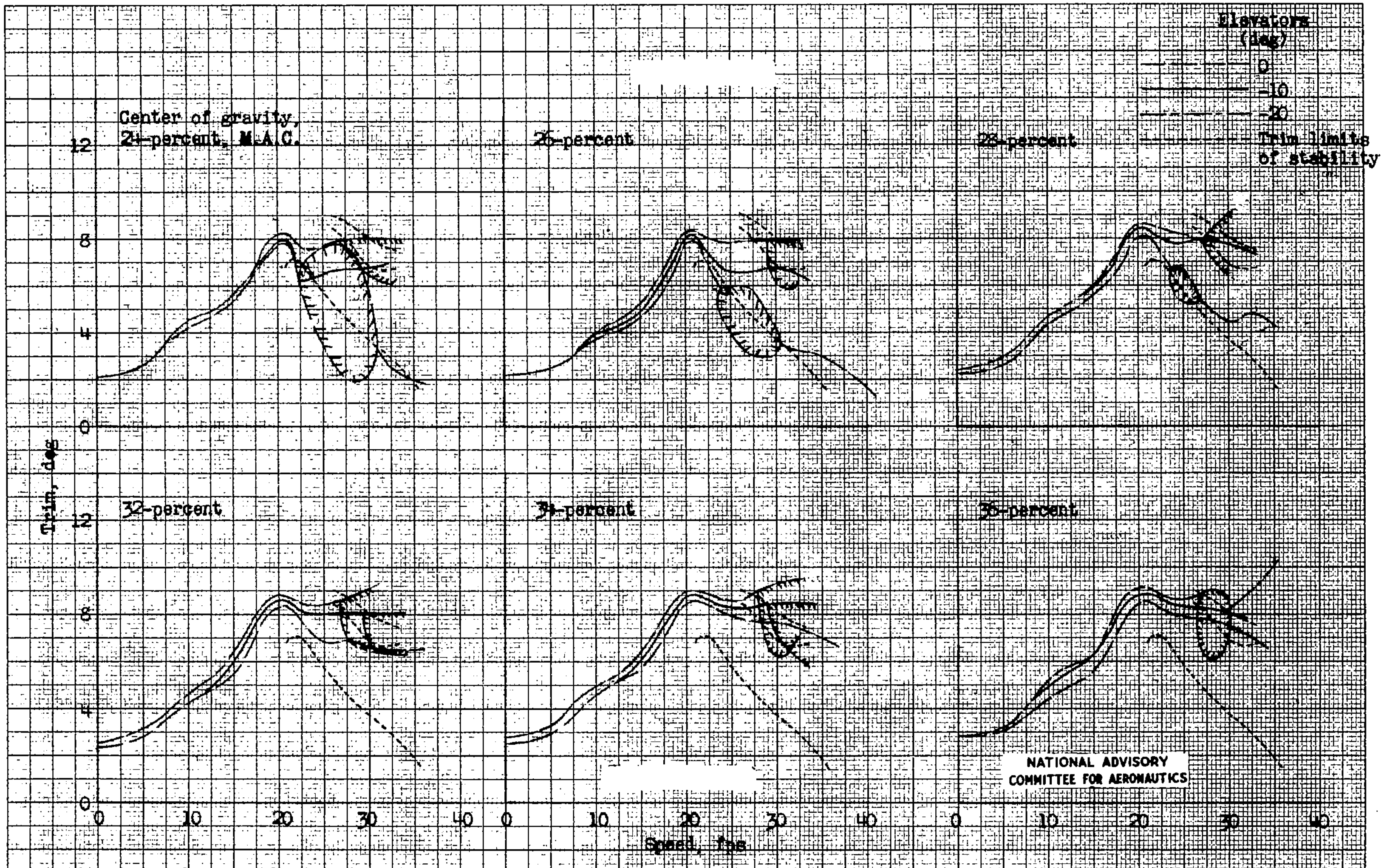
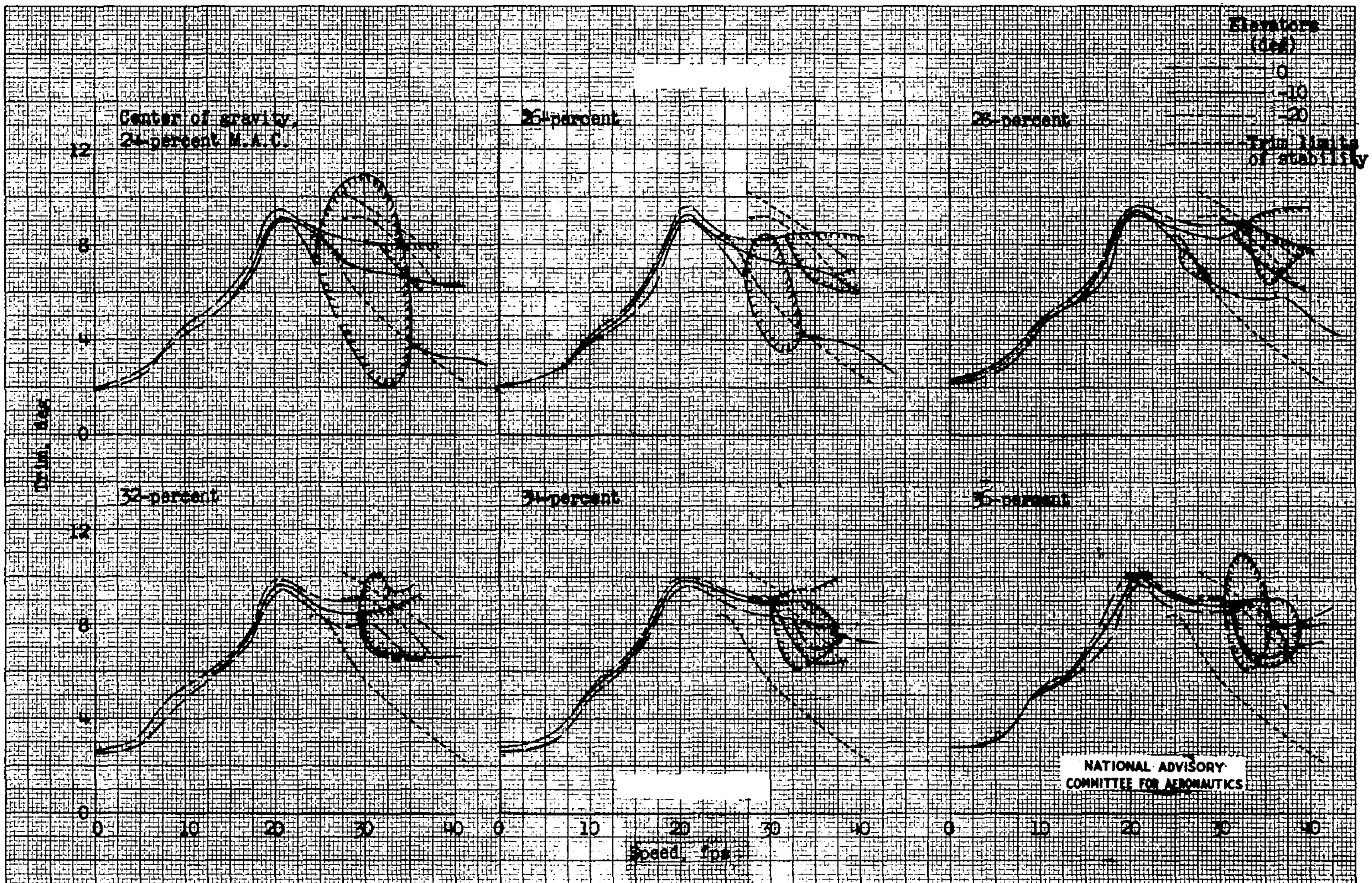


Figure 5 .- Model 203C-1. Trim limits of stability.



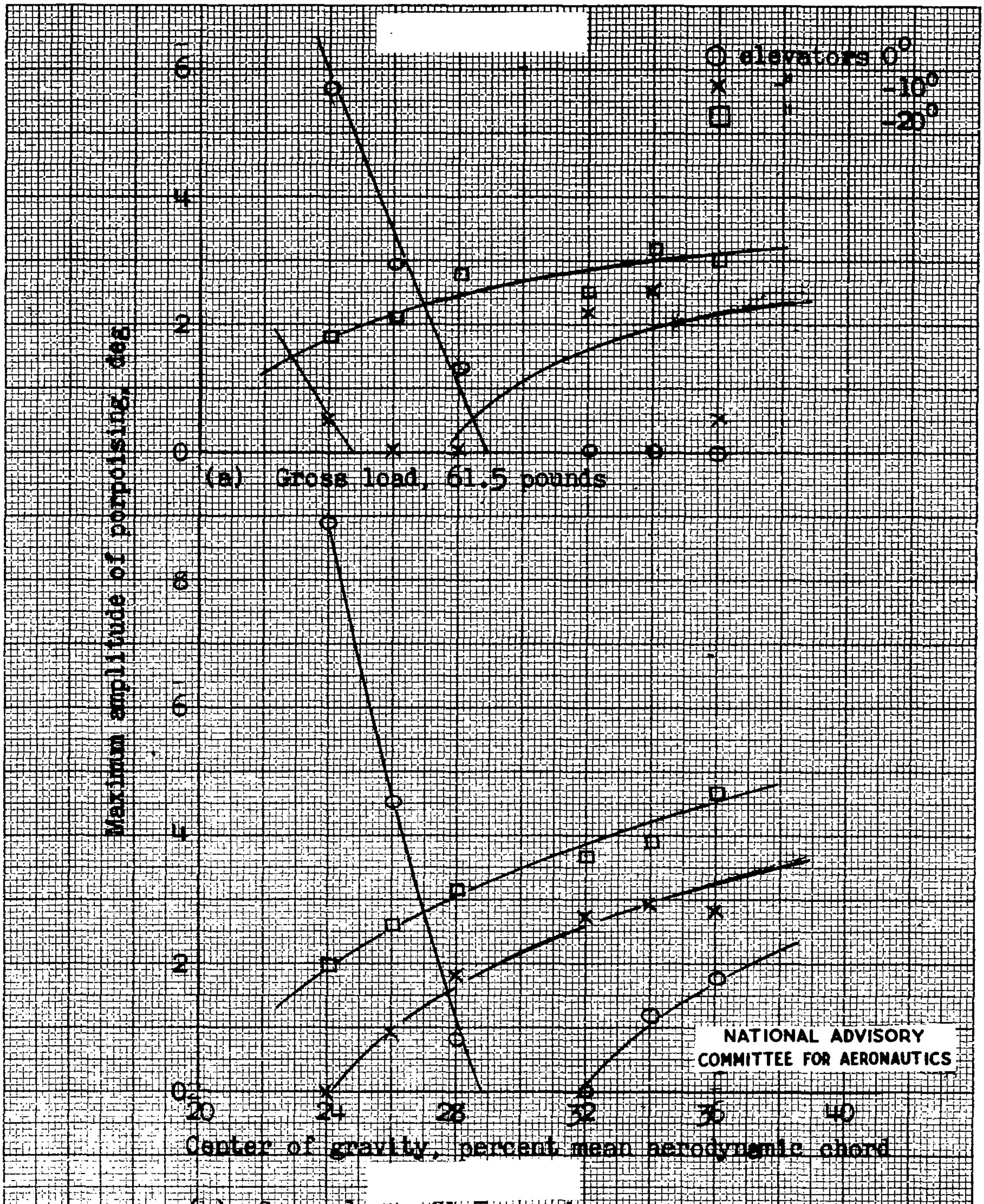
(a) Gross load 61.5 lb.

Figure 6.- Model 203C-1. Variation of trim with speed.



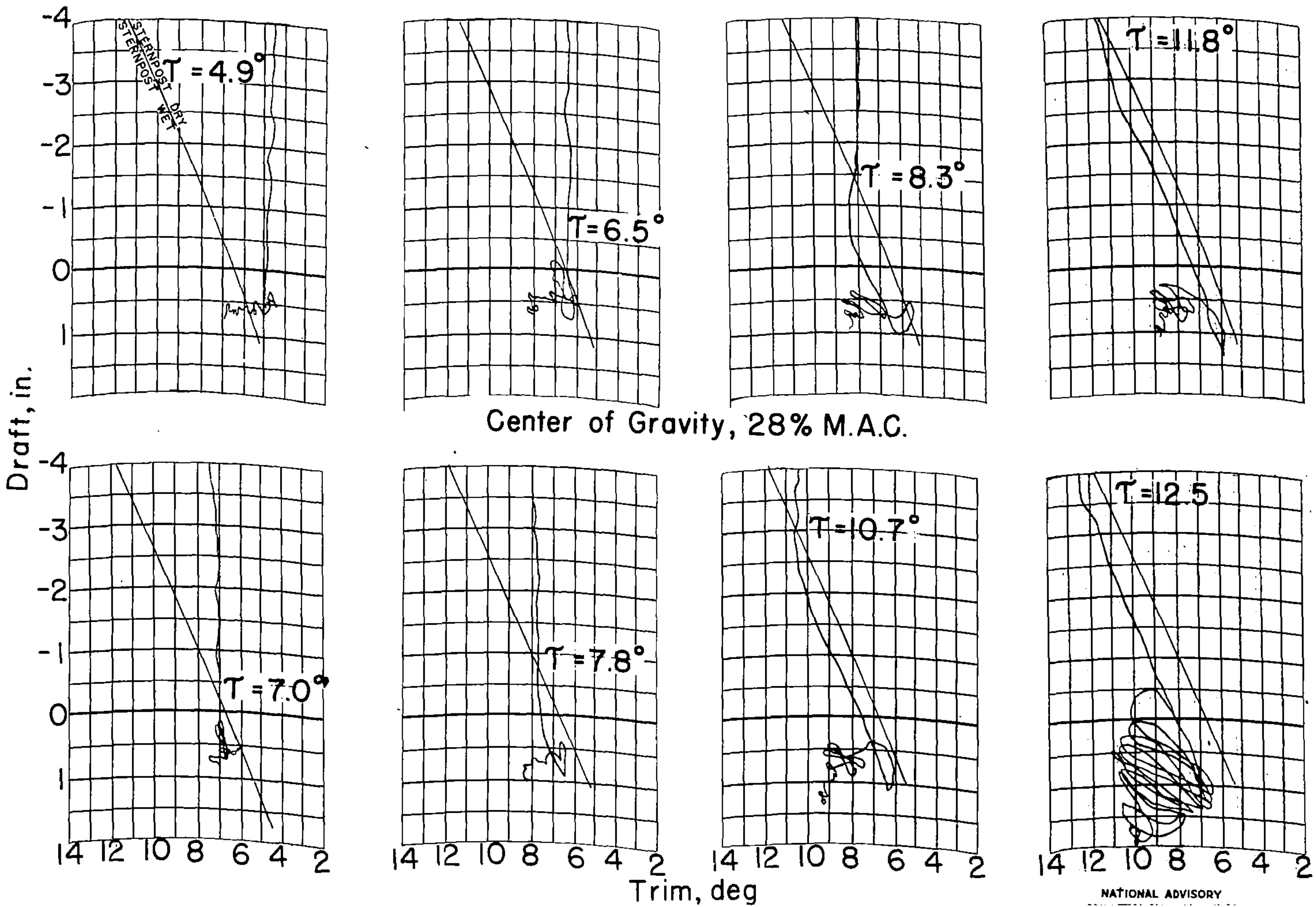
(b) Gross load, 81.5 lb.

Figure 6.- Concluded.



(b) Gross load, 81.5 pounds.

Figure 7.- Model 203C-1. Effect of position of the center of gravity on maximum amplitude of porpoising.



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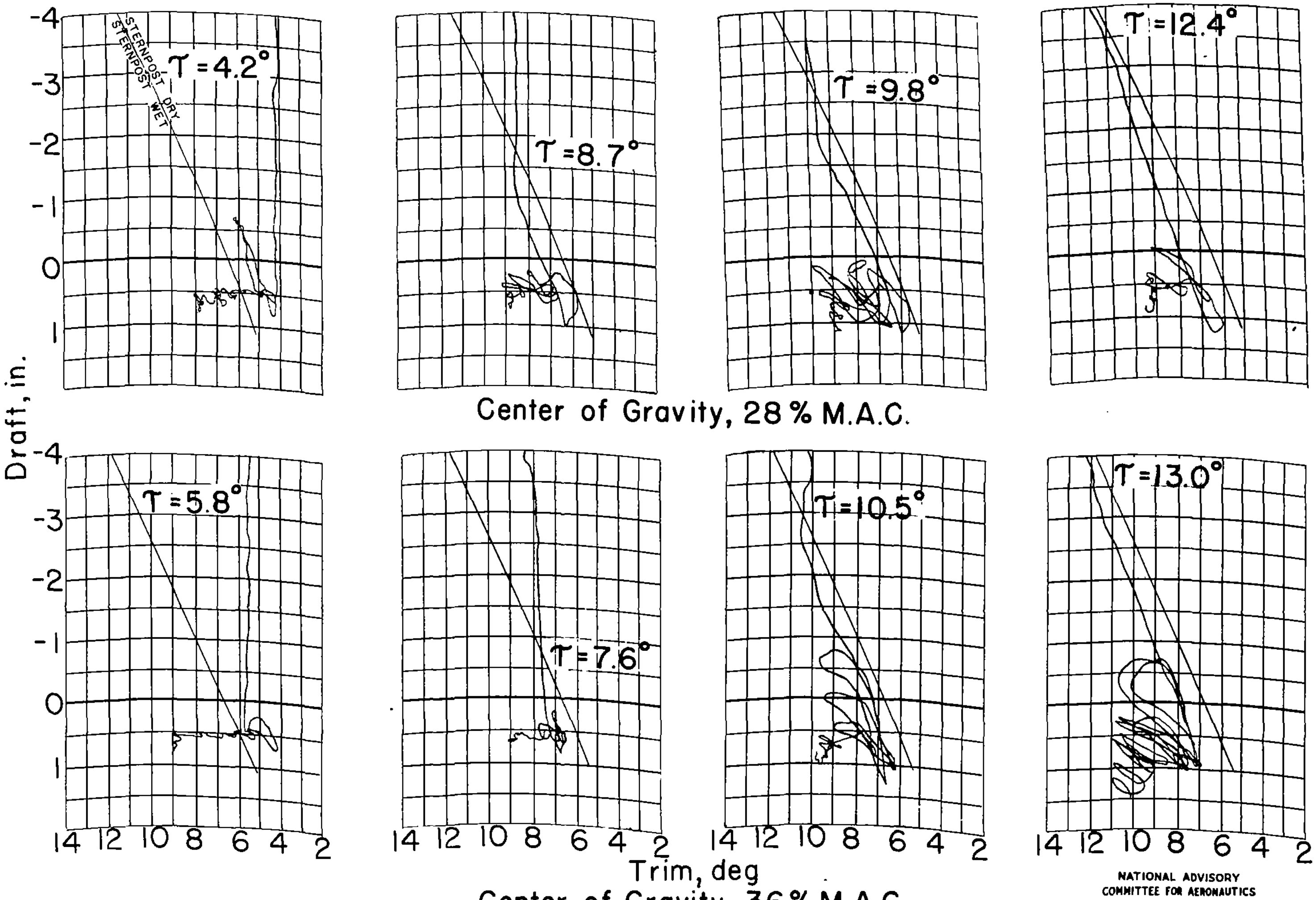

Figure 9.-Model 203C-1. Variation of trim and draft during landing.
Gross load, 81.5 pounds; 1/4 power; flap deflection, 20°.

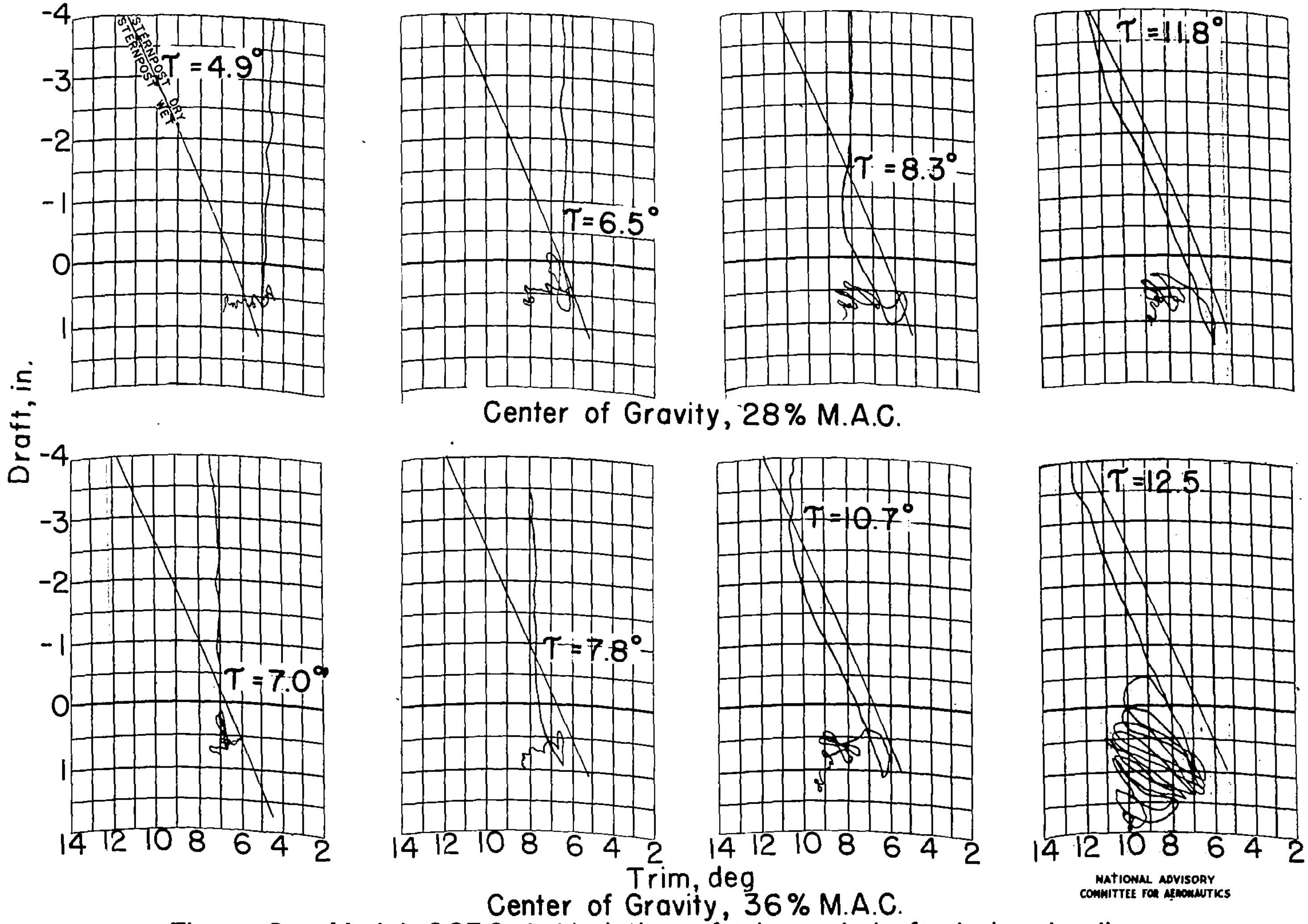

Figure 8 .-Model 203C-1. Variation of trim and draft during landing. Gross load, 61.5 pounds; 1/4 power; flap deflection, 20°.

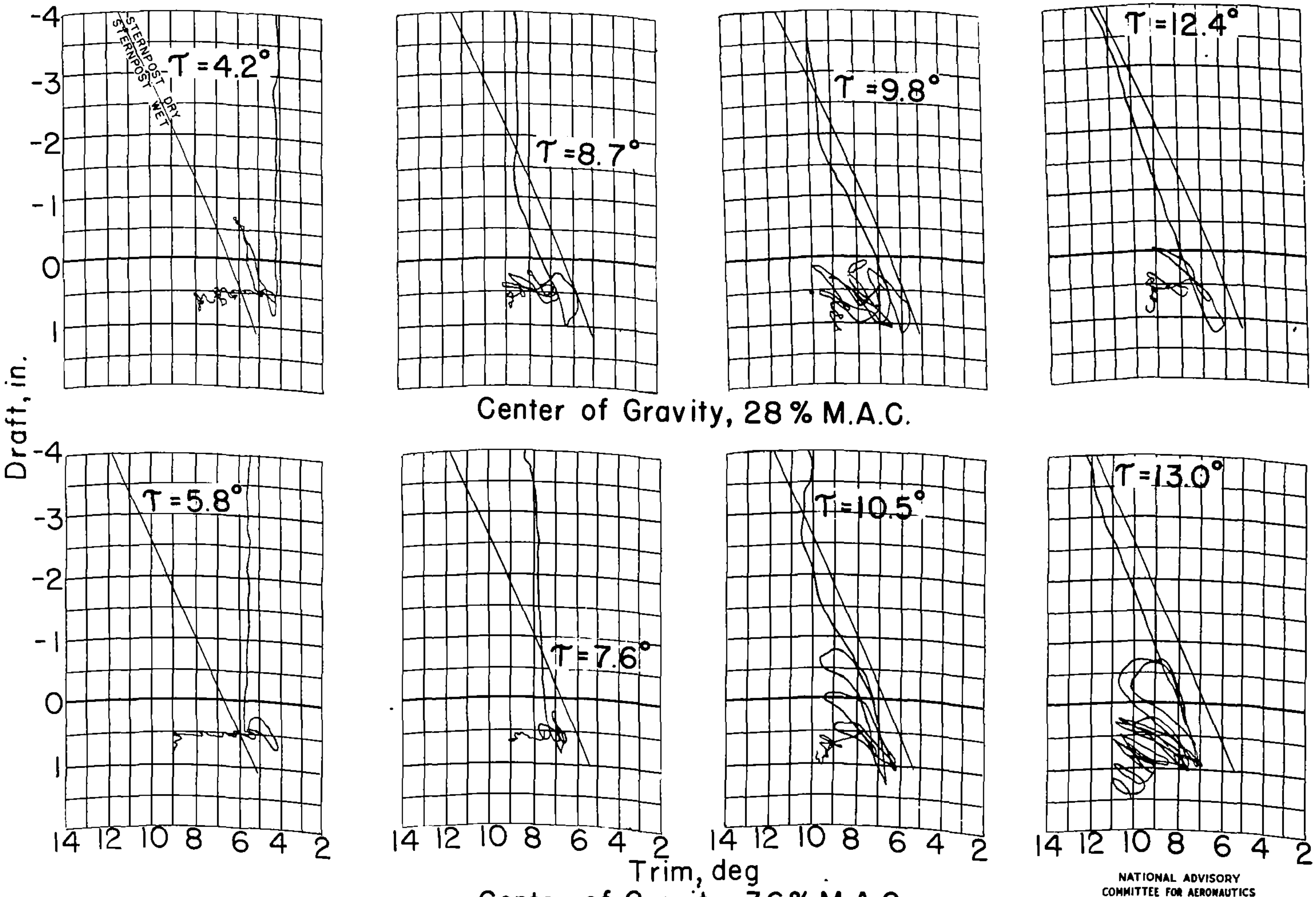

Figure 9.-Model 203C-1. Variation of trim and draft during landing. Gross load, 81.5 pounds; 1/4 power; flap deflection, 20°.

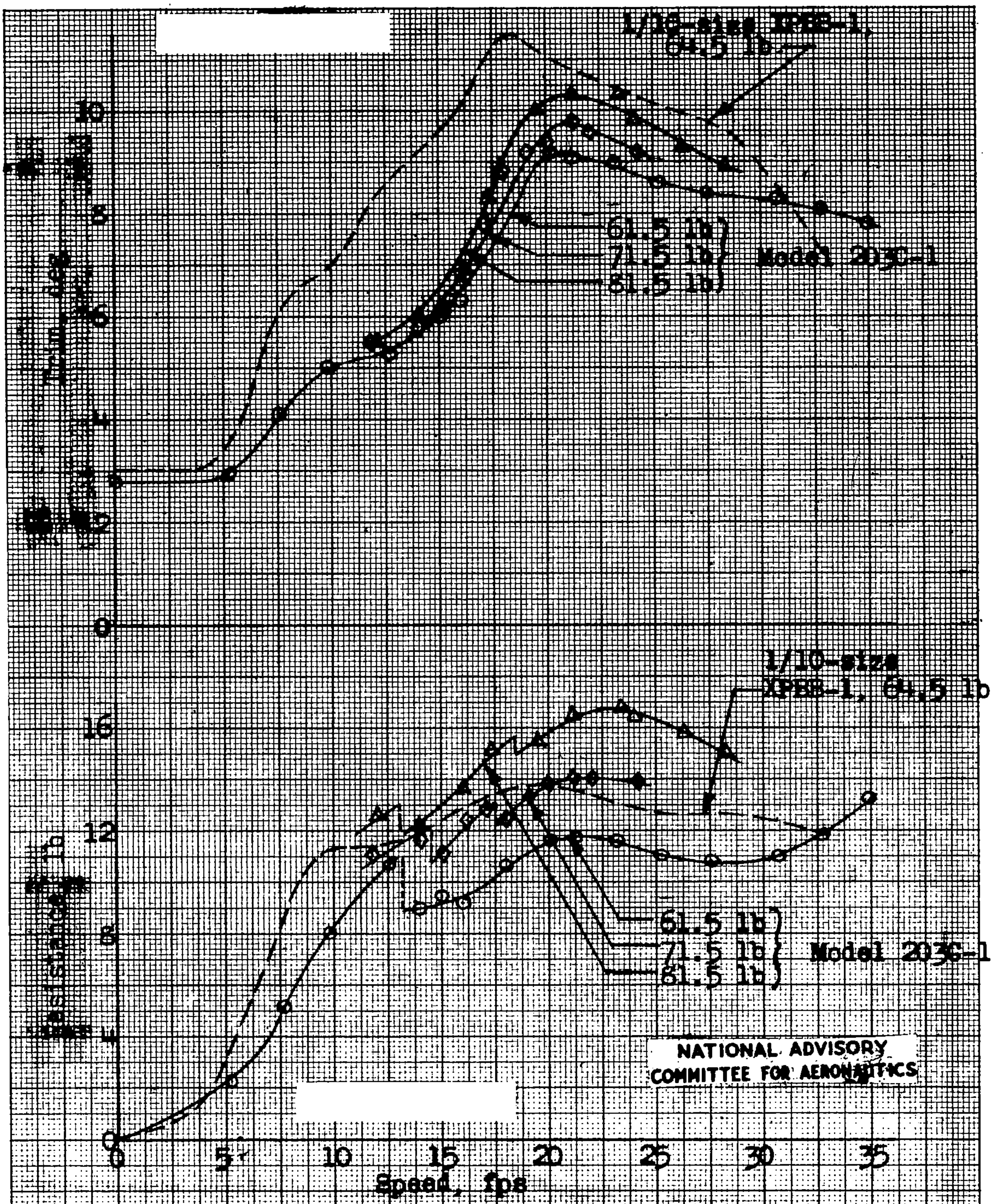

Figure 10.- Model 203C-1, total resistance and trim. Center of gravity 28 percent mean aerodynamic chord; elevator deflection, -10 degrees.